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Magnitude and impact of multiple chronic conditions with advancing age in older adults hospitalized with acute myocardial infarction☆

Mayra Tisminetzky [a,b,c], Hoa L. Nguyen [a,d], Jerry H. Gurwitz [a,b,c], David McManus [e], Joel Gore [e], Sonal Singh [b,c], Jorge Yarzebski [a], Robert J. Goldberg [a,b,e,*]

[a] Department of Quantitative Health Sciences, University of Massachusetts Medical School, Worcester, MA, United States of America
[b] Meyers Primary Care Institute, University of Massachusetts Medical School, Worcester, MA, United States of America
[c] Division of Geriatrics, Department of Medicine, University of Massachusetts Medical School, Worcester, MA, United States of America
[d] Department of Quantitative Sciences, Baylor Scott and White Health, Dallas, TX, United States of America
[e] Division of Cardiovascular Medicine, Department of Medicine, University of Massachusetts Medical School, Worcester, MA, United States of America

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ABSTRACT

Background: To examine age-specific differences in the frequency and impact of cardiac and non-cardiac conditions among patients aged 65 years and older hospitalized with acute myocardial infarction (AMI).
Methods: Study population consisted of 3863 adults hospitalized with AMI at 11 medical centers in central Massachusetts on a biennial basis between 2001 and 2011. The presence of 11 chronic conditions (five cardiac and six non-cardiac) was based on the review of hospital medical records.
Results: Participants' median age was 79 years, 49% were men, and had an average of three chronic conditions (average of cardiac conditions: 2.6 and average of non-cardiac conditions: 1.0). Approximately one in every two patients presented with two or more cardiac related conditions whereas one in every three patients presented with two or more non-cardiac related conditions. The most prevalent chronic conditions in our study population were hypertension, diabetes, heart failure, chronic kidney disease, and peripheral vascular disease. Patients across all age groups with a greater number of previously diagnosed cardiac or non-cardiac conditions were at higher risk for developing important clinical complications or dying during hospitalization as compared to those with 0–1 condition.
Conclusions: The prevalence of multimorbidity among older adults hospitalized with AMI is high and associated with worse outcomes that should be considered in the management of this vulnerable population.

1. Introduction

The prevalence of multiple coexistent chronic conditions (MCCs) in patients with cardiovascular disease has become increasingly common, especially as the U.S. and other industrialized populations age. Patients hospitalized with an acute myocardial infarction (AMI) and MCCs experience higher levels of healthcare use and suffer poorer health related outcomes than those without MCCs [1–8]. The clinical management of persons hospitalized with an AMI and MCCs is particularly challenging, due in part to their high risk for adverse events, as well as the need for complex and tailored therapeutic regimens [9].

Despite the high prevalence of MCCs in patients hospitalized for AMI, especially among older individuals, there are relatively limited contemporary data describing the magnitude of MCCs in older adults of different ages hospitalized with AMI, and possible age-specific differences in the effects of cardiac and non-cardiac related conditions on the risk of developing important clinical complications and dying during hospitalization for AMI [10–12].

The purpose of this large observational study was to describe the magnitude of cardiac and non-cardiac related multimorbidity, among older adults in three age strata (65–74, 75–84 and 85 years and older) hospitalized at all 11 central Massachusetts medical centers with AMI, and to examine the association between burden of cardiac and non-cardiac conditions with the risk of developing various adverse outcomes during admission to the hospital for AMI. Data from the population-based Worcester Heart Attack Study were used for purposes of this investigation [13–16].

2. Materials and methods

The Worcester Heart Attack Study is an ongoing population-based investigation that is examining long-term trends in the clinical epidemiology of AMI among residents of the Worcester, Massachusetts (MA), metropolitan area hospitalized at all medical centers in central MA on an approximate biennial basis [13–17].

☆ All authors take responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

* Corresponding author at: Division of Epidemiology of Chronic Diseases and Vulnerable Populations, Department of Quantitative Health Sciences, University of Massachusetts Medical School, 368 Plantation Street, Worcester, MA 01605, United States of America.
E-mail address: Robert.Goldberg@umassmed.edu (R.J. Goldberg).

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Computerized printouts of residents of central MA discharged from all 11 greater Worcester hospitals with possible AMI [International Classification of Disease (ICD) 9 codes 410–414, and 786.5] on a biennial basis between 2001 and 2011 were identified. Cases of possible AMI were independently validated using predefined criteria for AMI, including diagnoses of ST segment elevation myocardial infarction (STEMI) and non-ST segment elevation myocardial infarction (NSTEMI) [18,19]. This study was approved by the Institutional Review Board at the University of Massachusetts Medical School.

Trained nurses and physicians abstracted information on patient's demographic and clinical characteristics and hospital treatment practices and outcomes through the review of hospital medical records. These characteristics included patient's age, sex, race/ethnicity, hospital length of stay, and 11 previously diagnosed chronic conditions. These 11 chronic conditions were further classified into two groups: five Cardiac related conditions: atrial fibrillation, heart failure, hypertension, peripheral vascular disease, and stroke; and six Non-cardiac related conditions: anemia, asthma/chronic pulmonary disease, chronic kidney disease, dementia/Alzheimer, depression, and diabetes. Information on the development of important in-hospital complications including atrial fibrillation [20], cardiogenic shock [21], heart failure [22], stroke [23], and dying was collected through the review of hospital medical records. Data on the receipt of three coronary diagnostic and interventional procedures [cardiac catheterization, percutaneous coronary intervention (PCI), and coronary artery bypass graft surgery (CABG)] during hospitalization, and evidence-based pharmacotherapies during hospitalization, namely angiotensin converting inhibitors (ACE-I)/angiotensin receptor blockers (ARBs), aspirin, beta-blockers, and lipid lowering agents were also obtained.

2.1. Data analysis

We stratified our study population into three age groups for purposes of contrast and analysis, namely those 65–74 years old, 75–84 years old, and persons 85 years and older. We compared differences in the baseline demographic and clinical characteristics, hospital management practices, and in-hospital outcomes within each of these three age strata using chi square tests for categorical variables and the ANOVA test for continuous variables. We estimated the overall prevalence of the five cardiac and six non-cardiac related conditions and, based on the previous literature [24], included in this study any morbidity with a prevalence ≥5% in this patient population.

For purposes of more systematically examining the association between the number of cardiac and non-cardiac conditions previously diagnosed with the risk of dying or developing any of the examined important clinical complications (heart failure, stroke, cardiogenic shock, or atrial fibrillation) during hospitalization for AMI (as a single composite endpoint) among patients in the three age strata, we used logistic regression modeling and we adjusted for several potentially confounding demographic and clinical factors of prognostic importance in these models. These factors were chosen based on findings from prior studies and on their clinical importance. The variables we controlled for included sex, type of AMI (STEMI vs NSTEMI), AMI order (initial vs. prior), receipt of the examined cardiac interventions (cardiac catheterization, percutaneous coronary intervention, and coronary artery bypass graft surgery) and receipt of evidence- based cardiac medications during the index hospitalization (angiotensin converting enzyme inhibitors/angiotensin receptor blockers, aspirin, beta blockers, and lipid lowering medications). We created interaction terms between age and the number of chronic conditions previously diagnosed to examine whether the association between MCCs and the risk of developing our composite study endpoint differed according to age. We used likelihood ratio tests to compare models with and without our interaction terms.

3. Results

A total of 3863 residents of central MA 65 years and older were hospitalized with an independently validated AMI at all 11 greater Worcester medical centers during the six study years between 2001 and 2011. The median age of this patient population was 79 years and 48.9% were men. The average number of previously diagnosed chronic conditions in this population was 3.1 while the median was 3.0. The average number of cardiac conditions was 2.6 while the average number of non-cardiac conditions was 1.0.

3.1. Baseline characteristics according to patient's age at hospital presentation

Patients aged 75–84 years old were more likely to have been diagnosed with a NSTEMI and to have had a previously diagnosed AMI as compared with those 65–74 years old (Table 1). Patients 85 years and older were more likely to be women, Caucasian, to have been diagnosed with an NSTEMI, and to have presented with a previous AMI as compared with those aged 65–74 years old (Table 1).

Frequency of chronic conditions according to patient's age at hospital presentation.

Table 1
Patient demographic and clinical characteristics according to age among patients hospitalized with acute myocardial infarction.

Characteristic	65–74 years (n = 1186) (%)	75–84 years (n = 1540) (%)	≥85 years (n = 1137) (%)
Age (mean, years)	69.8	79.7	88.5**
Male	59.5	49.9	36.4**
White	86.9	93.1	95.5**
Non ST-segment myocardial infarction	68.7	75.1	78.7**
Initial myocardial infarction	61.9	59.9	59.2
Do not resuscitate order	12.9	29.4	61.4**
Medical history			
Anemia	8.9	13.8	19.1**
Atrial fibrillation	11.8	20.5	26.8**
Chronic kidney disease	21.3	23.6	29.7**
Chronic lung disease/asthma	26.0	24.9	20.6*
Dementia/Alzheimer	0.7	4.7	9.2**
Depression	14.5	16.7	17.8
Diabetes mellitus	45.5	39.7	27.1**
Heart failure	23.2	30.5	38.4**
Hypertension	79.5	80.5	81.5
Peripheral vascular disease	22.9	22.5	20.4
Stroke	11.5	16.9	14.7**
Cumulative number of morbidities			
Cardiac related			
2 or more	41.9	52.5	56.3**
Non-cardiac related			
2 or more	29.9	34.0	36.6*
In-hospital clinical complications			
Atrial fibrillation	19.6	28.3	31.2**
Cardiogenic shock	6.7	6.2	4.9
Heart failure	47.1	53.1	63.1**
Stroke	2.3	2.0	2.5
Death	8.3	12.9	14.9**
No complications	43.1	34.6	25.8**
Any 1 complication	41.1	44.3	49.6**
Any 2 or more complications	15.9	21.2	24.6**

* Significant at $p < 0.05$.
** Significant at $p < 0.001$.

Patients 75–84 years old and those 85 years and older were more likely to have been previously diagnosed with almost every one of the 11 chronic conditions examined in this study, with the exception of chronic pulmonary disease/asthma and diabetes, as compared with patients 65–74 years old (Table 1). The most prevalent chronic conditions in patients 65–74 years old were hypertension, diabetes, chronic pulmonary disease/asthma, heart failure, and peripheral vascular disease whereas the most prevalent chronic conditions among patients 75–84 years old were hypertension, heart failure, diabetes, chronic lung disease/asthma, and chronic kidney disease; similar disease patterns were found in patients 85 years and older. Almost one of every two patients across all age groups presented with two or more cardiac related conditions, whereas almost one in every three patients presented with two or more non-cardiac related conditions (Table 1).

3.2. In-hospital complications according to patient's age

Patients aged 75–84 years and those 85 years and older were more likely to have developed atrial fibrillation and heart failure during their index hospitalization for AMI as compared with those in the youngest age group. Approximately one in every six patients 65–74 years old, one in every five among those 75–84 years, and one in every four patients 85 years and older developed two or more serious in-hospital complications (Table 1).

3.3. Differences in hospital management practices according to patient's age and comorbidity burden

The proportion of patients aged 85 years and older who received all four evidence- based medications during their acute hospitalization was

Table 2
Hospital management practices according to age among patients hospitalized with acute myocardial infarction.

	65–74 years (n = 1186) (%)	75–84 years (n = 1540) (%)	≥85 years (n = 1137) (%)
Diagnostic/interventional procedure			
Cardiac catheterization	72.3	52.7	23.0**
Coronary bypass surgery	10.3	6.6	0.7**
Percutaneous coronary intervention	47.0	33.8	15.0**
Either coronary bypass surgery or percutaneous coronary intervention	55.8	39.9	15.7**
Medications			
Angiotensin converting enzyme inhibitors/ angiotensin receptor blockers	69.7	68.2	61.0**
Aspirin	93.3	91.5	89.2*
Beta blockers	91.2	88.7	87.8*
Lipid lowering medications	80.5	73.1	61.4**
Any 2 medications	13.8	19.5	28.0**
Any 3 medications	30.5	30.4	32.0
All 4 medications	55.7	50.1	40.0**

* Significant at $p \le 0.05$.
** Significant at $p \le 0.001$.

significantly lower as compared with those 65–74 years and those 75–84 years old (Table 2). The percentage of patients that received any diagnostic/interventional procedure was significantly lower in patients 85 years and older as compared with those 65–74 years and those 75–84 years old.

The proportion of patients aged 85 years and older who presented with two or more cardiac or non-cardiac related conditions who were treated with all four evidence- based medications during their acute hospitalization was significantly lower as compared with those who presented with fewer chronic conditions within the same age group (Table 3 A). The percentage of patients that received any diagnostic/interventional procedure was significantly lower across all age groups in those who presented with two or more cardiac or non-cardiac related conditions, and this proportion was noticeably lowest in those aged 85 years and older who presented with two or cardiac or non- cardiac related conditions (Table 3 B).

3.4. Multimorbidity and the risk of adverse hospital outcomes according to patient's age

After controlling for several potentially confounding demographic and clinical factors of prognostic importance, we found an increased risk of dying or developing any of the examined important clinical complications, namely AF, HF, stroke or cardiogenic shock, during hospitalization according to the number of previously diagnosed cardiac and non-cardiac chronic conditions across all age groups (Table 4).

4. Discussion

The results of this population-based observational study in nearly 4000 adults 65 years and older from a large central New England metropolitan area hospitalized with AMI suggest a high burden of cardiac and non-cardiac related conditions in these patients. Moreover, we observed an association between the presence of multiple cardiac and non-cardiac multimorbidities with the risk of developing important hospital clinical complications or dying during the patient's acute hospitalization.

4.1. Magnitude of multiple chronic conditions according to advanced age

Our results are consistent with the findings from previous studies which have shown that older patients (≥65 years) have a high burden of MCCs [24–27]. The most prevalent chronic conditions in our study population were hypertension, diabetes, heart failure, chronic kidney disease, and peripheral vascular disease.

Somewhat similar patterns of MCCs were found in a cross-sectional study of >1,750,000 ambulatory men and women who were treated at >300 Scottish general practices during 2007 [25]. Approximately one quarter of the study population aged 65–74 years presented with two or more chronic conditions whereas the proportion of persons 75 years and older with two or more conditions was 45% and 54%, respectively [25]. In the Swiss FIRE (Family Medicine ICPC Research using Electronic Medical Record) study of >98,000 adults enrolled in the Swiss healthcare system between 2009 and 2011, the prevalence of multimorbidity (two or more chronic conditions) increased with advancing age: 26% of those aged 60–69 years, 34% of those aged 70–79, and 38% in persons 80 years and older [27].

A limited number of prior studies have examined the magnitude and/or impact of MCCs at the time of hospitalization for AMI in different age strata [4,5,12,28]. Among nearly 17,000 patients diagnosed with a NSTEMI at 125 medical centers in Victoria, Australia between 2007 and 2009 (mean age = 75 years) [27], multimorbidity was more prevalent with advancing age; the prevalence of three or more chronic conditions among individuals aged <60, 60–74, and ≥75 years was 18%, 37%, and 46%, respectively [28].

Our population-based study builds on a limited prior literature showing that the proportion of elderly persons who present with

Table 3
A and B: Hospital management practices according to age and the frequency of cardiac and non-cardiac related conditions.

	65–74 years n = 1186			75–84 years n = 1540			≥85 years n = 1137		
	Only 2 medications	Only 3 medications	All 4 medications	Only 2 medications	Only 3 medications	All 4 medications	Only 2 medications	Only 3 medications	All 4 medications
Cardiac related									
0–1	13.6	29.3	57.0	20.9	29.6	49.5	25.8	29.8	44.5
2 or more	14.1	32.2	53.7	18.2	31.1	50.7	29.7	33.8	36.6
Non cardiac-related									
0–1	12.8	30.8	56.4	19.9	30.4	49.7	29.0	30.4	40.6
2 or more	16.3	29.9	53.8	18.7	30.3	51.0	26.2	34.9	38.9

	65–74 years n = 1186		75–84 years n = 1540		≥85 years n = 1137	
	No procedures	CABG or PCI	No procedures	CABG or PCI	No procedures	CABG or PCI
Cardiac related						
0–1	33.8	66.2	51.9	48.1	78.7	21.3
2 or more	58.6	41.5	67.6	32.4	88.6	11.4
Non cardiac-related						
0–1	36.6	63.4	54.5	45.5	80.9	19.1
2 or more	62.0	38.0	71.0	29.0	90.1	9.9

Table 4
Risk of developing the composite study endpoint during hospitalization for an acute myocardial infarction according to age and frequency of cardiac and non-cardiac related conditions.

	65–74 years (n = 1186)		75–84 years (n = 1540)		≥85 years (n = 1137)	
Composite outcome[c]	Unadjusted OR (95%CI)	Adjusted ORs (95% CI)	Unadjusted OR (95%CI)	Adjusted ORs (95% CI)	Unadjusted OR (95%CI)	Adjusted ORs[a] (95% CI)
Cardiac related[b]						
Chronic condition	2.99 (2.36;3.80)	2.09 (1.59;2.75)	2.05 (1.67;2.51)	1.62 (1.30;2.02)	1.98 (1.55;2.53)	1.81 (1.40;2.35)
Non-cardiac related[b]						
Chronic condition	2.04 (1.34;3.10)	1.39 (1.04;1.86)	1.55 (1.14;2.10)	1.86 (1.47;2.36)	1.01 (0.72;1.41)	1.22 (0.93;2.60)

[a] Models adjusted for sex, type of AMI and order (initial vs. prior), receipt of all four evidence-based cardiac medications (e.g., Angiotensin converting enzyme inhibitors/Angiotensin receptor blockers, Aspirin, Beta-blockers, Lipid lowering medications) and either coronary artery bypass surgery or a percutaneous coronary intervention. In the models in which we used cardiac-related conditions as a predictor of our composite study endpoint, we adjusted for the presence of non-cardiac related conditions and vice versa.
[b] Reference group are those individuals with 0–1 cardiac related or non-cardiac related chronic condition, respectively. A multiple chronic conditions variable, either cardiac or non-cardiac related, has been included as a continuous variable scaled according to every two chronic condition.
[c] Composite outcome is a combination of any of the examined clinical complications (AF, HF, stroke, or cardiogenic shock) or death during hospitalization for AMI.

MCCs at the time of hospitalization for AMI is significant. Since, however, there remains a lack of a gold standard on how to best define and characterize multimorbidity, and a lack of consensus around which diagnoses should be included when counting chronic conditions, further work remains needed on how to best assess and measure the overall burden of multimorbidity and how MCCs impact the management and clinical outcomes among older men and women hospitalized with various acute manifestations of underlying chronic diseases.

4.2. Hospital medical management practices according to age and multimorbidity

Our findings suggest that the proportion of older patients (85 years and older) with two or more cardiac or non-cardiac related conditions who received evidence- based cardiac medications and cardiac interventions was significantly lower as compared with the younger comparison groups.

Similar findings have been reported by other investigators [28–30]. A study of Medicare beneficiaries hospitalized with AMI reported that the utilization rates of aspirin, beta blockers, and coronary reperfusion therapy were lower in older elderly patients [29]. Data from the National Hospital Discharge Survey examining AMI related hospitalizations in the U.S. between 1979 and 2005 showed that patients aged 85 years and older were the least likely to have undergone coronary interventional procedures [30].

Published data on the effectiveness of various cardiac interventions in older patients with MCCs according to age are surprisingly scarce, although there is some evidence that suggests that elderly patients might receive greater benefits on survival from the receipt of these therapies than younger old patients [31]. In our previous study of 1137 patients ≥85 years hospitalized between 1997 and 2007 for AMI at all 11 metropolitan Worcester medical centers, the 90-day post-discharge survival improved significantly in these elderly patients during the years under study and these encouraging trends were primarily driven by the increased use of guideline-based cardiac medications [31]. Future clinical guidelines and pragmatic clinical trials might benefit from broadening their inclusion criteria to include elderly men and women who present with MCCs in order that health care providers can make better clinical management decisions about these high-risk complex patients.

4.3. Risk of developing important clinical complications during hospitalization for AMI according to age and number of chronic conditions

Our findings suggest that there was a significantly increased risk of developing any complication or dying during hospitalization for AMI according to the number of cardiac and non-cardiac related conditions across all age groups except in the association of non-cardiac conditions and adverse outcomes in those individuals aged 85 and over. Of special note, the association of non- cardiac related conditions and adverse outcomes was especially prominent among those aged <75 years.

There might be several potential explanations for our findings. The impact of MCCs may be different in younger versus older patients and other factors may be better predictors of important clinical outcomes in older adults with MCCs [32,33]. In the Health and Retirement Study, (n = 19,000) as the age of study participants increased, the association of MCCs and 1-year mortality was attenuated, whereas the association of functional limitations and mortality remained strong [32].

Other risk factors, such as functional status, frailty, presence of caregivers, or psychosocial factors might play a more important role in predicting patient's short and/or long-term outcomes, including the risk of dying after an acute coronary syndrome among the elderly [32–36]. A study of Medicare enrollees showed that function-related parameters (e.g., delirium/dementia, mobility limitations) were strongly associated with the risk of dying within 12 months after hospital discharge for AMI [34]. Coupled with our findings, prior data would support the hypothesis that MCCs, especially non-cardiac related conditions, may have less of an impact on the development of adverse outcomes than other factors including frailty, functional limitations, or psychosocial impairments during hospitalization for AMI in men and women of different ages and with varying frequencies and types of MCCs [32].

4.4. Study strengths and limitations

This study has several strengths including its population-based design that captured the vast majority of cases of AMI that occurred among residents of central MA during the years under study. Several limitations need to be kept in mind, however, in interpreting the present findings. First, data on chronic conditions were abstracted from hospital medical records and we did not have information available about the duration, severity, or extent of these previously diagnosed conditions. The majority of our study population was Caucasian and we did not have information available on several patient associated characteristics (e.g., socioeconomic status, functional status, and cognitive impairment) which may have confounded the observed associations, and how these factors may have differed according to age and presence of MCCs. We restricted our study outcomes to the development of in-hospital events to focus our analysis on the highest risk period for developing adverse outcomes in older patients of different ages hospitalized for AMI and to minimize the potentially confounding influence of other unmeasured factors that might have developed after being discharged from the hospital after an AMI.

5. Conclusions

The results of our study suggest that MCCs are highly prevalent and impactful in elderly patients who are hospitalized for an AMI. Future research investigations should examine the impact of various therapeutic interventions in patients with AMI of different ages with MCCs on both patient-centered and clinical outcomes to determine the best ways to treat and monitor these high risk and complex patients and identify

those chronic conditions, singly and in combination, that are most impactful.

Abbreviations

ACE-I	angiotensin converting inhibitors
AMI	acute myocardial infarction
ARBs	angiotensin receptor blockers
CABG	coronary artery bypass graft surgery
MCCs	multiple chronic conditions
STEMI	ST segment elevation myocardial infarction
NSTEMI	non-ST segment elevation myocardial infarction
PCI	percutaneous coronary intervention

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Conflict of interest

The authors report no relationships that could be construed as a conflict of interest.

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